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REPORT ON SULPHUR DIOXIDE INJURY IN COMMERCIAL SHIPMENTS OF TOKAY GRAPES

1942 SEASON

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INTRODUCTION

Although sulphur dioxide injury had been reported occasionally on Tokay grapes by market inspectors, it was not until 1941 that it was observed to occur very generally throughout most of the shipments that were examined on the eastern markets. The injury consisted of small bleached pits on the skin of the grapes that became more noticeable a day or two after the fruit was removed from the refrigerator car. The injury was so widespread and was believed to be so serious as to warrant some effort to prevent it. The Tokay Marketing A greement enlisted the services of the U. S. Department of Agriculture in 1942 to make an investigation of the problem.

METHODS

It was not known whether or not injury had escaped notice in the many years sulphur dioxide had been used on Tokay grapes or whether it had become more serious in recent years. The evidence seemed to point to the former conclusion because the dosages of gas used in treating Tokay grapes the last few years were not as great as they had been previously. There was a factor, however, that favored the possibility that injury had increased. This was the increased use of precooling and the generally adopted practice of fumigating the grapes afterward when they were at a temperature favoring condensation of moisture upon them. The cause of the pitting was attributed to the absorption of the gas by the drops of moisture on the grapes. This question was investigated in the present studies.

The test cars were commercial shipments that were fumigated according to the general practice. Although there are several methods used in fumigating grapes, the most common one in the Tokay district is known as the "Esotoo" process. It would have been preferable to have tried several methods of application but this was not possible since the shippers who had cars destined for New York that could be used for test purposes all employed the "Esotoo" process.

The fumigating equipment used consisted of a small cylinder containing the required amount of gas for the car, a water bath in which the cylinder was heated, and a mixing device that was inserted through a false door set in one-half of the doorway of the car. When the water bath reached the boiling point, the valve on the cylinder was opened releasing gas under high pressure into the tube-like mixer through which air from outside the car was drawn and mixed with the gas as it was discharged into the car. The hatches of the car were open during application to permit the escape of air as it was displaced by the air-gas mixture. As soon as all of the gas had been released from the cylinder, the hatches were closed, the false door and mixer were removed and the car door was shut.

Gas concentrations were read during fumigation with a portable gas sampling apparatus in which sulphur dioxide was determined by the iodine-thiosulphate method. Gas samples were taken from various parts of the car shortly after the start of the gassing period and at intervals during the following 30 to 50 minutes.

Test lugs of grapes, all selected from one lot of fruit and packed similarly were usually placed in the load in the top layer of the doorway stack where concentrations would be high and in the middle layer of the quarter-length stack where they would probably be lower. Test lugs were also placed in the top layer of the bunker stack and the bottom layer of the doorway stack in some cars. Non-gassed lots were placed in position in the cars after the gas treatment was completed.

Transit temperature records were obtained with recording thermometers packed in the test lugs and temperatures at the end of precooling were read with mercury thermometers in five parts of the load. The humidity and dew-point of the outside air were determined at the time of fumigation to ascertain whether conditions were favorable for condensation.

Inoculations were made with gray mold spores (Botrytis sp.) through small slits in the side of the grapes and the inoculated berries, usually twenty or more, were marked with ink to identify them. However, in most cases a sufficiently long incubation period for the fungus to become established was not available before the fruit was precooled and the result was that many of the inoculations did not take, even in the control lots.

A first inspection was made of the test packages upon arrival at New York without disturbing the pack. The tops and bottoms of the lugs were removed and the exposed, decayed berries were counted. The percentage of the fruit showing sulphur dioxide injury and the aggregate area affected was estimated from a sample of 25 to 50 grapes taken from the test lugs. A second inspection was made after the grapes had been held at room temperature for three days when all the grapes were examined for decay and another sample was inspected for injury.

RESULTS

Test 1 - September 17, 1942. Precooled $5\frac{1}{4}$ hours to 50°F., gassed with 4 pounds, Esotoo process, shipped with one reicing, fan car.

Test lugs were placed in this car in the top layer doorway stack and the middle layer quarterlength. The fruit was only fairly mature, some of the grapes testing 15 to 16 percent soluble solids, with the lot averaging 19.3 percent. As indicated in figure 3, the gas concentrations were not high at either position, there being a maximum of 0.8 percent at middle quarterlength and 0.4 percent at top doorway

ten minutes after the start of fumigation, which diminished to about 0.1 percent at each position in 30 minutes. There was considerable delay in closing the car door and consequently some loss of gas which may account for the unusual condition of higher gas concentrations at the middle quarterlength than at the top doorway. Transit temperatures were not low in this car; the top-layer doorway required 6 days to cool to 47° (fig. 1).

When the car arrived 15 days after loading there was 1 to 3 percent gray mold rot showing in the commercial lines of fruit in the car, but no sulphur dioxide injury was noticed except on an occasional berry that had been torn loose from the capstem. When the test lugs were inspected on arrival (table 1) it was evident that the gas treatment had stopped the growth from the inoculations, for no mold was in evidence. There was some bleaching and definite sinking of tissue at each puncture indicating that the gas treatment had cauterized the wounds. No other sulphur dioxide injury was found at the time but after four days at fruit-stand temperatures it was evident under careful scrutiny (table 1), being present as small bleached spots 1/32 inch in diameter. About half the grapes were so affected in each of the lugs that had been gassed and usually 2 to 4 spots occurred on each berry but about 10 percent of the grapes bore from 5 to 15 spots. It should be pointed out that although injury was widespread, the bleached spots were so small that they would probably escape notice by the average consumer. The effectiveness of sulphur dioxide in checking decay was demonstrated by the large number of moldy berries in the ungassed lug as compared with the treated lugs.

Table 1 - Inspection of grapes in Test 1

Treatment	Decay		SO_2
	Berries 1/	Inoculations taken	Injury 2/
	No.	Pct.	pct.
	Condition on arrival (berries in face only)		
Top doorway, precooled, gassed	0	0	0
Top doorway, precooled, not gassed	28	45	0
Top doorway, not precooled, gassed	20	--	0
Mid. quarter, precooled, gassed	7	0	0
	Condition 4 days after arrival (total cont. lug)		
Top doorway, precooled, gassed	23	0	Considerable
Top Doorway, precooled, not gassed	403	50	None
Top doorway, not precooled, gassed	115	--	Considerable
Mid. quarter, precooled, gassed	12	0	Some

1/ Does not include inoculated berries since some lugs had none. There were about 2,000 to 2,500 berries per lug, hence 20 to 25 berries would represent about 1 percent of the fruit.

2/ Small bleached pits, 1/64 to 1/32 inch in diameter affecting about 50 percent of the berries, 2 to 15 spots per berry.

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Test lots of grapes that had been precooled and gassed in this car (top layer, doorway stack) were also held at shipping point for 11 days at 36° to 38°F. and upon removal were normal in every respect, showing no mold or sulphur dioxide injury. After 3 days at 70 to 80°, bleached pits 1/16 to 1/8 inch in diameter appeared on some of the grapes and while the damage was not conspicuous or extensive it was definitely sulphur dioxide injury.

Test 2 - September 28, 1942.
S.F.R.D. 31367

Precooled in warehouse for 12 hours to 40°, ice replenished after loading reiced once in transit. Gassed with 6 pounds, Esotoo process.

Four test boxes of fruit were placed in the top layer doorway stack of this car. Two of these were handled in the regular manner, that is, trucked directly from the precooling room to the car, and the other boxes were allowed to stand outside the room for about 2 hours so that moisture would condense on the fruit. The dewpoint of the air was approximately 56°F., and as indicated the fruit was 40° as it came from the precooling room, hence condensation took place. These "sweating" packages were gassed along with the other fruit in the top layer of the car. The grapes used in this test were of average maturity, with soluble solids ranging from 18 to 21 percent, averaging 19.1 percent.

Temperatures were fairly low in transit, being 40 to 45°F. in the top layer for most of the trip (figure 1). The commercial load was in excellent condition upon arrival and there was no decay or conspicuous gas damage. When the test boxes were examined those that had been allowed to sweat before gassing had every berry pitted. In the lugs loaded directly into the car only about 2/3 of the berries were affected. The bleached sunken spots in both cases were 1/16 to 1/64 inch in diameter. The capstems and main stems of the nonsweated fruit were browner and drier than those of the sweated lots. No decay or mold was found in any of the lugs.

Final notes were taken on this test shipment 3 days after arrival to learn how the fruit from this car behaved after it left the wholesaler and reached retail markets. The fruit in the two sweated lugs was worse in respect to both mold and injury than in the lugs handled normally (table 2).

Table 2 - Inspection of test grapes in test 2 - 3 days after arrival.

Treatment	Decayed berries	SO_2 injury	
		Pct. berries	Av. surface Pct.
Sweated lugs	29	100	3.1
Unsweated lugs	2	86	1.8

Test 3 - October 2, 1942. P.F.E. 51836.

Precooled for 5 hours to 45°, shipped with one reicing. Gassed with 6 pounds, Esotoo process.

Test boxes of grapes were loaded in the top layer of the doorway and bunker stacks and the middle layer of the quarterlength stack of this car. Some pack-

ages were handled in the usual manner in that they were precooled and then fumigated, and other lugs were not precooled but were gassed when they were still warm in order to avoid condensation. Some ungassed fruit was shipped in the top layer doorway for comparison with the gassed fruit. The grapes were well matured, having soluble solids ranging from 18 to 23 percent, averaging 20 percent.

Transit temperatures in the top layer doorway stack were 40° to 48° for most of the trip (figure 1). The car arrived in New York on October 14, twelve days after shipment. Sulphur dioxide injury in the form of small bleached spots was widespread throughout some of the lugs, (table 3). The fruit at the top doorway position, gassed after precooling, was the most seriously affected and the nonprecooled lug at the same position was next in the extent of injury. Fruit from the middle quarterlength and top bunker where concentrations of SO_2 were not as high as they were at the doorway showed less injury. Decay was of no consequence on arrival in any of the treated or untreated lugs and none of the inoculations, even those that were not gassed, showed mold growth.

Table 3 - Inspection of grapes in test 3.

	Decayed berries	SO_2 injury	
		Berries	Surface
Treatment	No.	Pct.	Pct. (berries in face only)
	Condition on arrival		
Top doorway, precooled, gassed	0	100	2.9
Middle quarter, precooled, gassed	0	32	0.6
Top doorway, not precooled, gassed	0	60	1.4
Top bunker, precooled, gassed	1	4	trace
Top doorway, precooled, not gassed	0	0	0
Top bunker, precooled, not gassed	0	0	0
	Condition 3 days after arrival (Total contents of lug)		
Top doorway, precooled, gassed	36	100	2.9
Middle quarter, precooled, gassed	13	100	2.2
Top doorway, not precooled, gassed	22	93	2.3
Top bunker, precooled, gassed	52	56	0.8
Top doorway, precooled, not gassed	64	0	0
Top bunker, precooled not gassed	103	0	0

A second inspection of the fruit shipped in this car was made after 3 days storage at approximately 70°F. (table 3) and at this time sulphur dioxide injury was again the least prevalent in the lug from the top layer bunker stack. This lug showed more decay than any of the treated lugs, however. There was an increase in injury in all of the lugs not totally affected at the first inspection. Again in this test the pitting was small and inconspicuous and, as indicated in table 3, the total surface affected was small even when 100 percent of the berries were involved. The concentrations of gas at the doorway and quarterlength were evidently high enough to give some control of decay over the untreated lugs and the lug at the top bunker.

The fruit removed from the car at shipping point after gassing also showed

considerable injury when inspected six days later after holding it at room temperature. The bleached, sunken areas were from 1/16 to 1/4 inch in diameter and they were usually at places on the fruit where the bloom had been rubbed off the skin or where the sides of the berries had been flattened by pressure against the box. Injury was about the same in the fruit gassed after precooling and that gassed before it was precooled.

Test 4 - October 2, 1942. P.F.E. 14665 Precooled in warehouse, averaged 47° when loaded, shipped with one reicing in transit, gassed with 6 pounds, Esotoo process.

The gas concentration at the doorway was about 1.4 percent two minutes after the start of gassing, in ten minutes it was 1 percent and in twenty minutes 0.4 percent (figure 3).

Three test lugs were shipped in this car, two of which were precooled before they were gassed and the remaining lug was neither precooled nor gassed. The fruit was fairly mature, testing 17.4 to 23.4 percent soluble solids, averaging 21 percent. The car was shipped to Philadelphia, necessitating the shipment of the test packages to New York by express. They arrived in extremely poor condition with much shattering in evidence. No inspection was made until 3 days after arrival (table 4). All the berries in the two treated lugs were speckled and there was much decay present ranging from 25 and 40 percent in the gassed lots to as much as 70 percent in the untreated lot.

Table 4 - Inspection of grapes in test 4 after three days holding.

Treatment	Decayed berries	SO_2 injury	
		Berries	Surface
	Pct.	Pct.	Pct.
Top doorway, precooled, gassed - lot 1.	40	100	4.2
Top doorway, precooled, gassed - lot 2.	25	100	3.5
Top doorway, not precooled, not gassed	70	0	0

Test 5 - October 2,1942 P.F.E. 41862. Precooled in warehouse, average 49° when loaded, shipped with one reicing in transit, gassed with 6 pounds, Esotoo process.

The gas concentrations at the doorway were similar to those obtained in car 4 (figure 3), reaching 1.4 percent four minutes after the start of gassing and falling rapidly to 0.6 percent in six minutes and to 0.4 percent in twenty minutes. At the top bunker and middle quarterlength they were much lower, reaching a maximum of only about 0.5 percent.

The test fruit loaded in this car was fairly mature, ranging between 18 and 21 percent soluble solids and averaging about 20 percent. The dewpoint of the air was low, about 42°F. when this car was loaded; and since the fruit temperatures were higher than this for the most part, there was no condensation on the fruit. Transit temperatures were moderately cool, starting at about 50° in the top layer and cooling gradually to 40° on arrival (figure 1).

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The test lugs on arrival had injury showing much in proportion to the concentration of gas they were exposed to in the car. The lug from the top layer doorway had the most injury and the one from middle quarterlength the least in the lot gassed after precooling (table 5). The lug that was gassed without precooling had somewhat less injury than the companion lugs handled in the usual manner but it also had more decay.

Table 5 - Inspection of grapes in test 5.

Treatment	Decayed berries	SO$_2$ injury	
		Berries	Surface
	No.	Pct.	Pct.
	Condition on arrival		(Berries in face only)
Top doorway, precooled, gassed	0	76	1.9
Top bunker, precooled, gassed	0	68	1.6
Top doorway, nonprecooled, gassed	0	56	0.7
Middle quarter, precooled, gassed	0	36	0.4
Top doorway, precooled, not gassed	3	0	0
Top bunker, precooled, not gassed	1	0	0
	Condition 3 days after arrival		(Total contents lug)
Top doorway, precooled, gassed	9	100	3.5
Top bunker, precooled, gassed	23	100	2.0
Top doorway, nonprecooled, gassed	32	88	2.6
Middle quarter, precooled, gassed	16	48	0.6
Top doorway, precooled, not gassed	153	0	0
Top bunker, precooled, not gassed	42	0	0

Three days after arrival, injury was more prevalent in all the treated lugs. The fruit from the middle quarterlength was again conspicuous in having less gas injury than the other test lugs. It was surprising to find injury as widespread as it was in the top layer of the bunker stack, considering the relatively low concentrations of sulphur dioxide that were found in this part of the car.

Gas damage, affecting about 50 percent of the grapes was also noticed in fruit removed from the car and held at shipping point for six days at 70° to 80°. The injury, consisting of small pits about 1/8 inch in diameter, was noticeable enough to detract from the appearance of the fruit. It was again observed that bruised places on the berries were often seriously pitted. A lug that was gassed without having been precooled had less injury, only about 10 percent of the grapes showing pitting as compared to 50 percent in a companion lug gassed after precooling.

Test 6 - October 7, 1942. P.F.E. 74900 Precooled to 49°, shipped under standard refrigeration. Gassed with 6 pounds, Esotoo process.

Fruit used in this test averaged about 22 percent soluble solids and was representative of late season shipments. Temperatures in transit were not low during the first four days, especially in the top layer of the bunker stack, but they were close to 40° for the last 4 or 5 days in transit (figure 2).

Concentrations of sulphur dioxide were more uniform in this car than in other test cars receiving the same amount of gas. The reason for this is not known

but it may be that the short time in which the gas was applied, 4 minutes, indicating high velocities from the mixer, might have resulted in more uniform distribution. Leakage from the car at the doorway may also have helped to lower concentrations at that position. At any rate, the maximum concentration was only a little over 0.8 percent as compared to 1.4 percent in earlier test cars.

Gas injury was considerably less prevalent in this car, especially at the top layer doorway, than it was in the other test cars used in these studies (table 6). This was no doubt due to the better distribution of gas which prevented high concentrations at the doorway.

Table 6 - Inspection of grapes in test 6.

Treatment	Decayed berries	SO_2 injury	
		Berries	Surface
	No.	Pct.	Pct.
	Condition on arrival (Berries in face only)		
Top doorway, precooled, gassed, Lot 1	0	40	0.6
Top bunker, gassed, precooled, Lot 2	0	32	0.4
Top doorway, gassed, precooled, Lot 2	4	28	0.4
Middle quarter, precooled, gassed, Lot 1	0	4	trace
Top bunker, precooled, gassed, Lot 1	0	4	trace
Top bunker, precooled, not gassed, Lot 1	0	0	0
Top doorway, precooled, not gassed, Lot 1	0	0	0
	Condition 3 days after arrival (Total contents of lug)		
Top doorway, precooled, gassed, Lot 1	12	76	1.1
Top bunker, gassed, precooled, Lot 2	37	88	1.6
Top doorway, gassed, precooled, Lot 2	10	56	0.9
Middle quarter, precooled, gassed, Lot 1	28	32	0.3
Top bunker, precooled, gassed, Lot 1	22	28	0.4
Top bunker, precooled, not gassed, Lot 1	51	0	0
Top doorway, precooled, not gassed, Lot 1	115	0	0

Test 7 - October 7, 1942. P.F.E. 96725 Precooled to 49°, shipped with one reicing in transit. Gassed with 6 pounds before precooled. Esotoo process.

Test 7 was one in which gassing before precooling was compared with the more common method of gassing after precooling employed in test 6. Some of the grapes from car 7 were loaded in the latter car. These were designated as lot 2 (table 6). This fruit had a wide range in soluble solids, 15 to 22 percent, averaging 19 percent.

The grapes were warm when car 7 was gassed, having temperatures of 76° to 83°. Maximum sulphur dioxide concentrations were high at the doorway reaching 1.3 percent and there was not a good distribution of gas in the car (figure 4). The precooling fans were started about an hour after gassing and in 15 minutes most of the sulphur dioxide had been cleared from the air of the car and the ungassed fruit was placed in the load.

Transit temperatures were not as low in this car as they were in car 6 (figure 2) and 5 days in transit were required to cool the top layer to slightly less than 50°.

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All of the grapes in the test lug in the top layer doorway showed gas injury on arrival, that in the middle layer quarterlength had 40 percent of the berries damaged and the fruit at the top layer bunker stack showed no injury (table 7). Three days later there was still no injury apparent in the fruit from the top layer bunker stack but it was as badly affected with decay as the fruit that had not been gassed.

Table 7 - Inspection of grapes in test 7.

Treatment	Decayed berries	SO_2 injury	
		Berries	Surface
	No.	Pct.	Pct.
	Condition on arrival (Berries in face only)		
Top doorway, gassed, precooled	1	100	2.2
Middle quarter, gassed, precooled	2	40	0.4
Top bunker, gassed, precooled	1	0	0
Top doorway, not gassed, precooled	2	0	0
Top bunker, not gassed, precooled	3	0	0
	Condition 3 days after arrival (Total contents of lug)		
Top doorway, gassed, precooled	16	100	3.6
Middle quarter, gassed, precooled	66	36	0.4
Top bunker, gassed, precooled	216	0	0
Top doorway, not gassed, precooled	211	0	0
Top bunker, not gassed, precooled	203	0	0

When the condition of the test fruit in cars 6 and 7 was compared, there was more injury at the top layer doorway in the latter car, gassed before precooling, than there was in car 6, which was gassed after precooling. The higher gas concentrations (figure 4) and the warmer fruit temperatures in car 7 probably accounted for this. At the top layer bunker stack conditions were reversed, for car 6 had higher gas concentrations than car 7 and injury was greater here. This test indicated that gassing before precooling would not prevent injury.

Test 8 - October 23, 1942. S.F.R.D. 23391 Warehouse precooled, 49° when loaded, shipped under standard refrigeration, gassed with 6 pounds, Esotoo process.

A final test was made in car 8 late in the season. The test fruit had soluble solids ranging from 18.2 to 21.8 percent, averaging 20.6 percent. Transit temperatures in this car were 45° or less at the top layer, doorway stack and about 38° at the middle layer quarterlength for most of the trip.

Gas concentrations taken at the doorway at the floor and at the top of the load were found to be similar, starting at about 1.4 percent a few minutes after the first gas was introduced into the car and dropping rapidly to about 1.0 percent in 10 minutes and to 0.5 percent in 20 minutes. Middle layer, quarterlength had concentrations of about 0.9 percent at the start which diminished to about 0.4 percent in 20 minutes (figure 4).

When the test fruit was inspected on arrival, all of it showed gas damage, the top layer doorway lugs that were precooled before gassing having the most. Decay was more prevalent in the sweated fruit than in that loaded directly into the car but gas damage was not greater (table 8). The fruit at the bottom layer doorway

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showed less injury than that in the top of the same stack probably because it had less surface exposed because it was buried in the load.

Table 8 - Inspection of grapes in test 8.

Treatment	Decayed berries	SO_2 injury	
		Berries	Surface
	No.	Pct.	Pct.
	Condition on arrival (Berries in face only)		
Top doorway, precooled, gassed	3	80	1.6
Top doorway, precooled, sweated, gassed	27	76	1.5
Middle quarter, precooled, gassed	3	44	0.6
Top doorway, nonprecooled, gassed	2	40	0.5
Bottom doorway, nonprecooled, gassed	0	36	0.4
Middle quarter, precooled, sweated, gassed	8	32	0.5
	Condition 3 days after arrival (Total contents of lug)		
Top doorway, precooled, gassed	48	96	2.7
Top doorway, precooled, sweated, gassed	189	94	2.5
Middle quarter, precooled, gassed	34	92	1.9
Top doorway, nonprecooled, gassed	54	100	2.7
Bottom doorway, nonprecooled, gassed	21	90	1.9
Middle quarter, precooled, sweated, gassed	62	84	2.1

At the second inspection 3 days later all of the lugs showed much more injury and decay (table 8). The 3 lugs from the top layer doorway stack had the most injury and the sweated lugs had the most decay.

SUMMARY

The injury encountered in these tests with Tokay grapes consisted of bleached pits on the skin, often so small as to escape notice. In some cases they were conspicuous enough to detract from the appearance of the fruit but usually this was not so. The results of these tests indicated that exposure for 20 to 30 minutes to very low concentrations of sulphur dioxide (0.2 percent and less) will cause pitting of the skin and that injury is not dependent upon the presence of moisture on the grapes. Consequently, it does not appear that sulphur dioxide pitting could be prevented by gassing the grapes before they were precooled although care should be taken to prevent condensation of moisture on the grapes; this usually resulted in more decay and sometimes in more injury.

There was usually a direct relation between the extent of injury and the concentration of gas to which the fruit was exposed. Grapes in the doorway stack showed the most injury because it was here that concentrations were highest. Better distribution of gas is needed to prevent too high concentrations in this part of the car. A small fan might be used at the brace to force the air-gas mixture throughout the load. It may be that the pressure under which the gas is applied, the speed of application, and the direction of the nozzles are important in attaining good distribution within the car; but records covering these points are needed before definite recommendations can be made.

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Benefits in the control of decay were usually obtained from gassing when the treatment was severe enough to cause some injury. This does not mean that the high concentrations (1.4 percent) commonly found at the doorway were needed, for in some cases just as effective control was obtained with lower concentrations. These tests indicated, however, that slight injury probably cannot be avoided and that the problem is one of preventing serious injury.

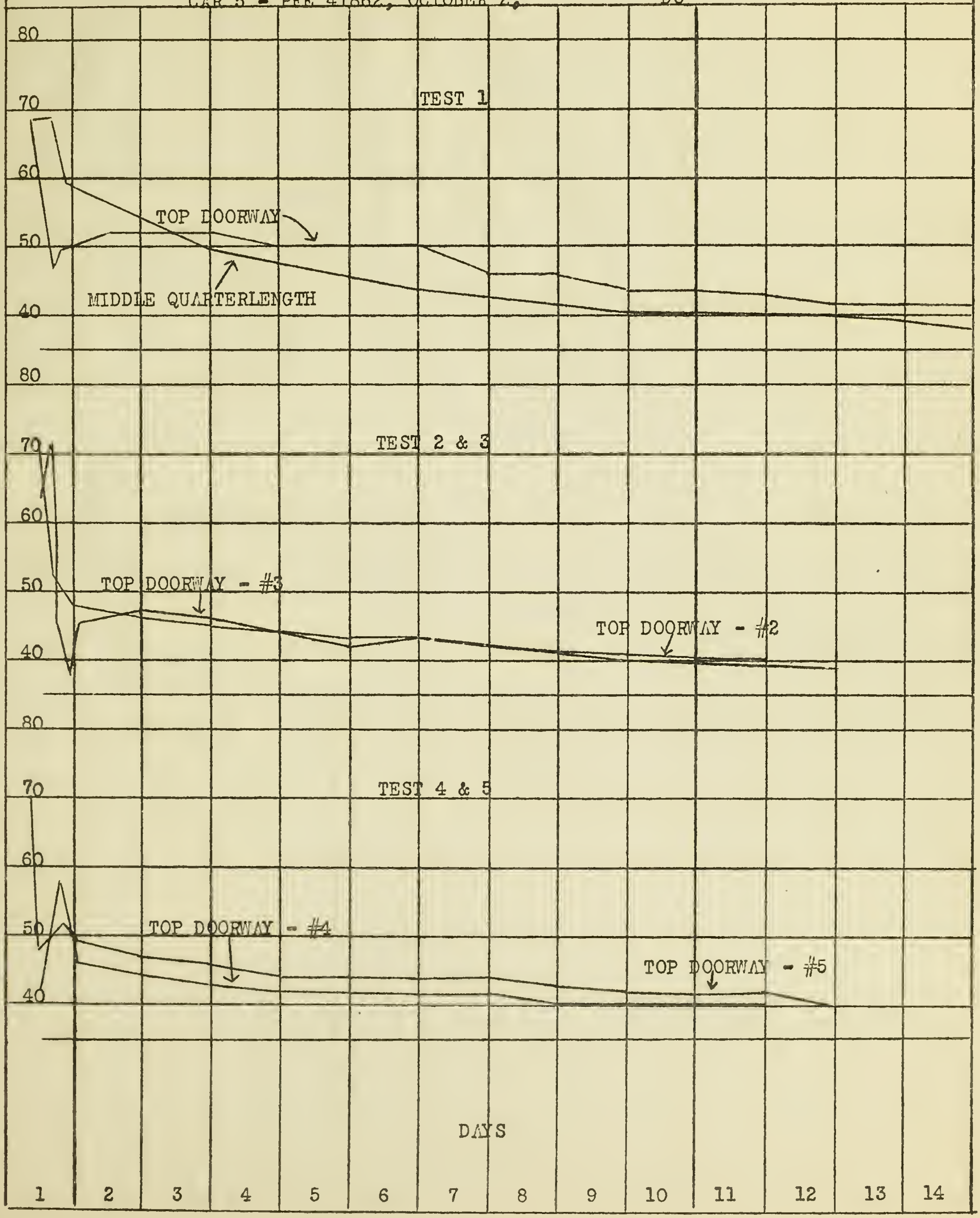
ACKNOWLEDGMENTS

The assistance of various individuals and the facilities provided by shippers and the fumigation service serving them are gratefully acknowledged.

* * * * * * * * * * * * * * * * *

FIGURE 1 - TEMPERATURES OF GRAPES IN TRANSIT - 1942

CAR 1 - PFE 76131, SPETEMBER 17, PRECOOLED, 1 REICING.
CAR 2 - SFRD 31367, SEPTEMBER 18 DO
CAR 3 - PFE 51836, OCTOBER 2, DO
CAR 4 - PFE 14665, OCTOBER 2, DO
CAR 5 - PFE 41862, OCTOBER 2, DO



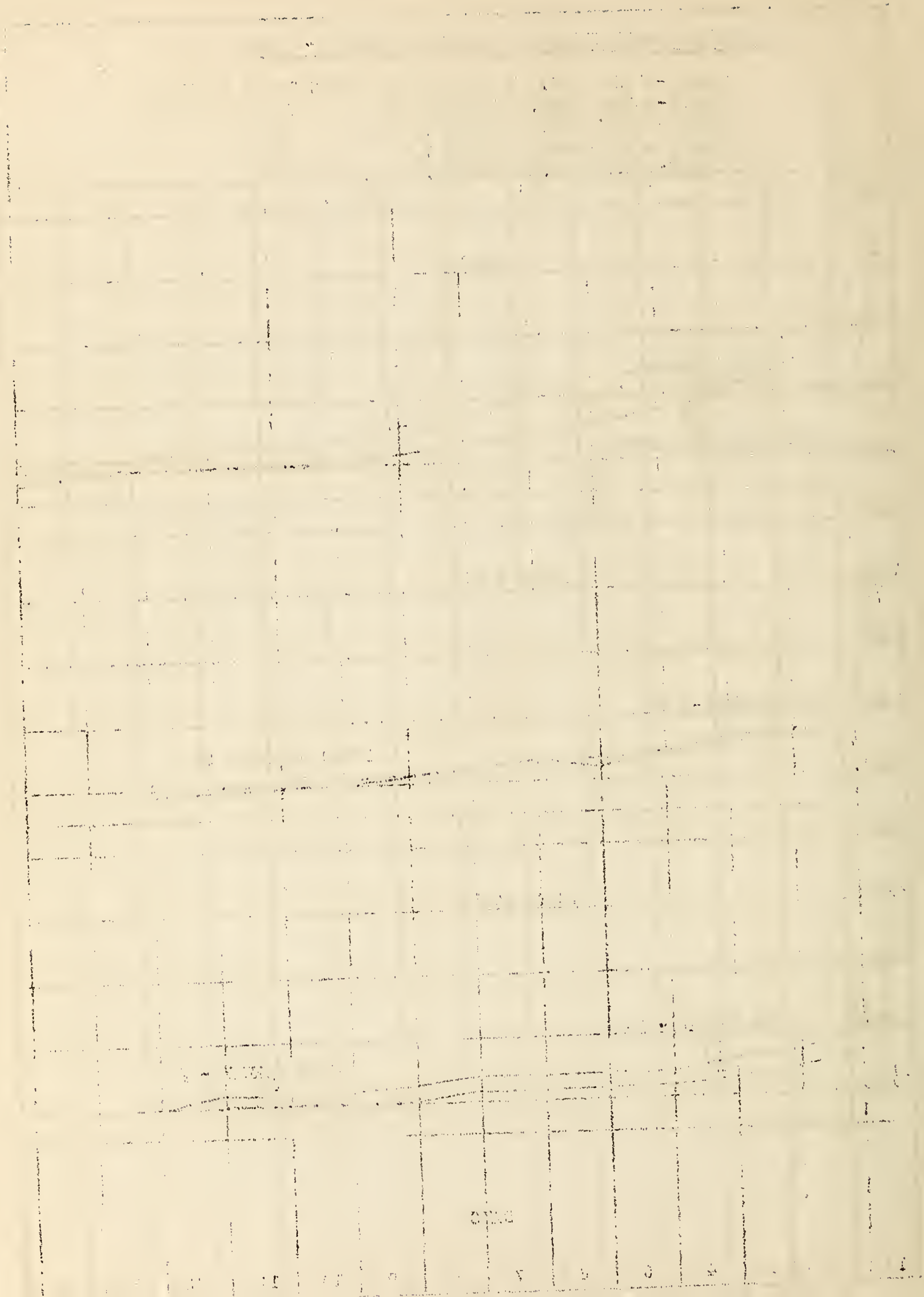
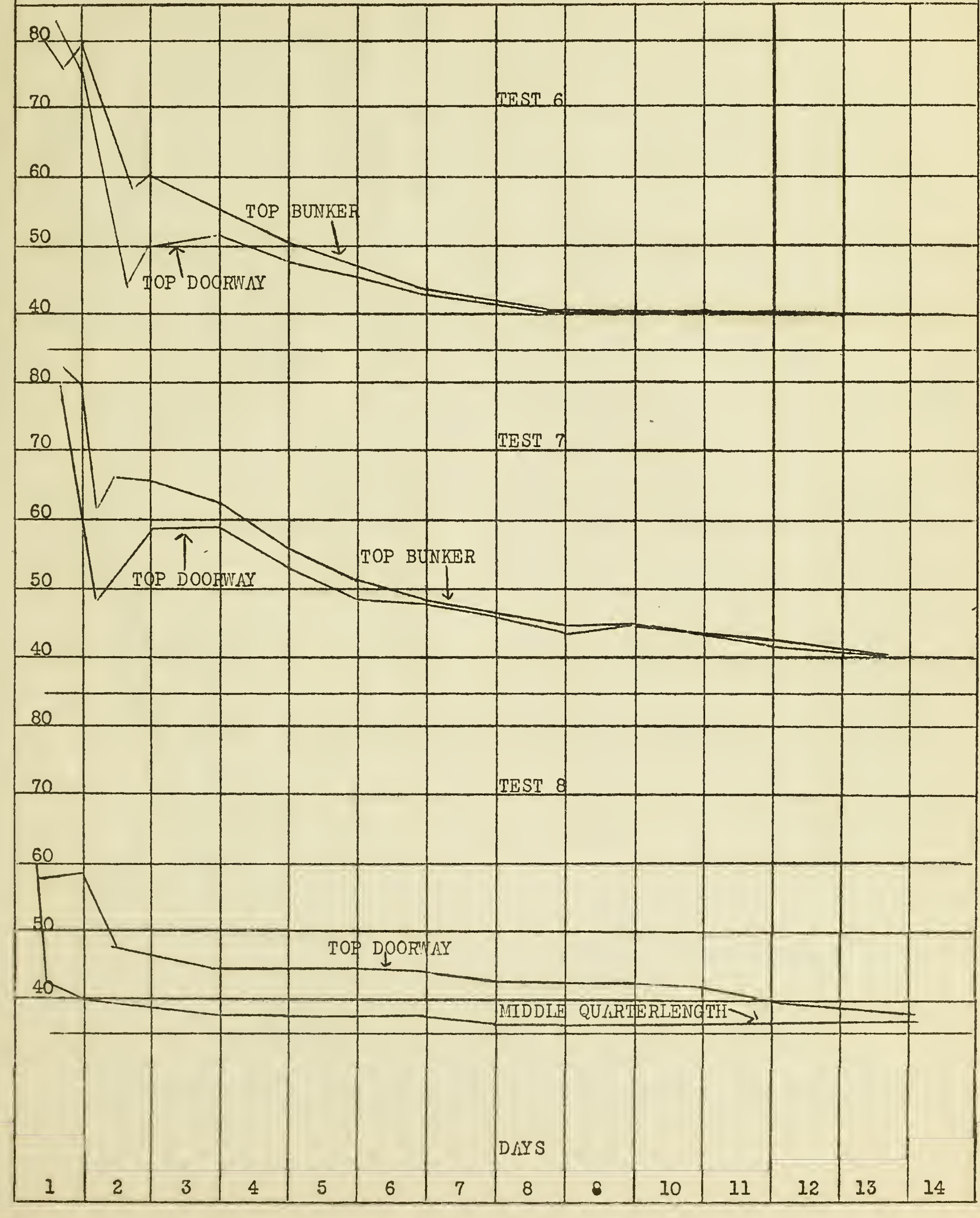


FIGURE 2 - TEMPERATURES OF GRAPES IN TRANSIT - 1942

CAR 6 - PFE 74900, OCTOBER 7, PRECOOLED STANDARD REFRIGERATION.
CAR 7 - PFE 96725, OCTOBER 7, PRECOOLED 1 REICING.
CAR 8 - SFRD 23391, OCTOBER 23, PRECOOLED STANDARD REFRIGERATION.



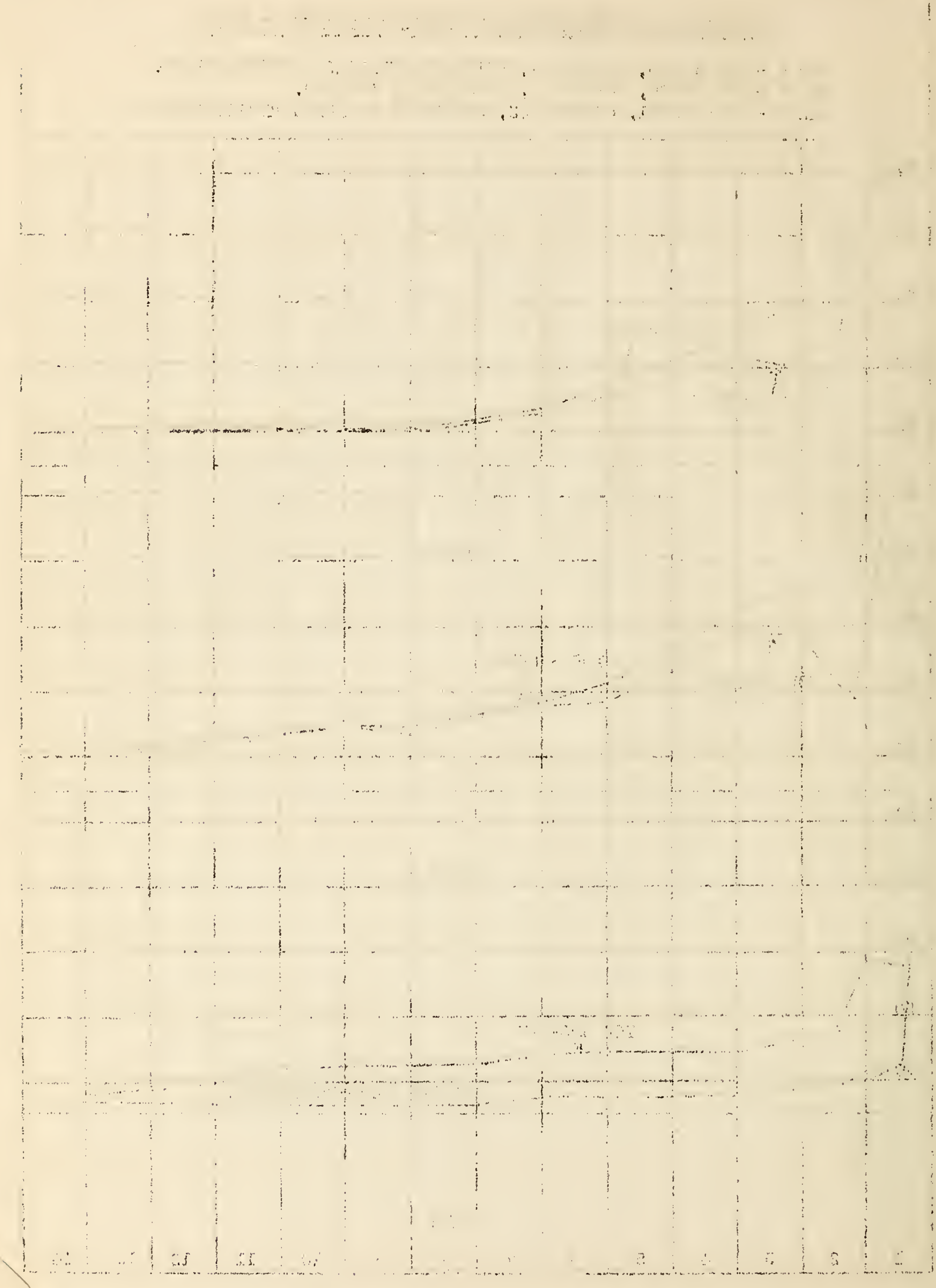


FIGURE 3 - Sulphur Dioxide Concentrations in Test Cars